

## Glossary

**acid deposition:** A complex chemical and atmospheric process that occurs when emissions of sulfur, nitrogen, and other substances react with particles, water droplets, oxygen, and oxidants to form acidic compounds. These compounds are often transported long distances by wind and then deposited to the environment by clouds, rain, and other meteorological events. Dry deposition takes the form of acidic gases or particles that settle out of the air onto the environment without the help of precipitation. Dry deposition makes up approximately 40 percent of total acid deposition. CASTNet monitors acidic forms of dry deposition by measuring sulfur dioxide ( $\text{SO}_2$ ), particulate sulfate ( $\text{SO}_4^{2-}$ ), nitric acid ( $\text{HNO}_3$ ), particulate ammonium ( $\text{NH}_4^+$ ), and particulate nitrate ( $\text{NO}_3^-$ ). Wet deposition, commonly called “acid rain,” occurs when acid compounds are washed out of the air by cloud vapor, rain, fog, snow, and other forms of precipitation. Discharges of sulfur and nitrogen from the burning of fossil fuels such as coal and oil are the primary sources of the sulfur and nitrogen oxides that are released into the atmosphere to form acid deposition.

**aerosol pollutants:** Very small particulate matter, either solid or liquid, suspended in the atmosphere. Aerosols often contain sulfur and can result from volcanic eruptions and from the burning of fossil fuels. See Chapter 2 of the CASTNet 2000 Annual Report (Harding ESE, 2002) for a discussion of the how the active Kilauea Volcano in Hawaii affects the atmosphere.

**alkanes:** Paraffins that include methane, ethane, propane, and butane gases. Aliphatic hydrocarbons having the general formula  $\text{C}_n \text{H}_{2n+2}$ .

**alkenes:** Olefins that include ethylene gas. Alkenes are unsaturated hydrocarbons having the general formula  $\text{C}_n \text{H}_{2n}$  and are highly chemically reactive.

**ambient air:** Surrounding air in prevailing conditions.

**anion:** A negatively charged ion. Anions measured by CASTNet include particulate sulfate ( $\text{SO}_4^{2-}$ ) and particulate nitrate ( $\text{NO}_3^-$ ). Anion-based acidic deposition can be neutralized if sufficient cations are present.

**anthropogenic:** Produced by human activities.

**aromatic hydrocarbons:** Chemical compounds containing the six-carbon ring characteristic of the benzene series and related organic groups. Examples of aromatic hydrocarbons include benzene, toluene, naphthalene, anthracene, and phenanthrene.

**atmospheric deposition:** See acid deposition.

**blanks:** See field blanks, laboratory blanks, method blanks, and trip blanks.

**boundary layer effects:** See inversion layer.

**cation:** A positively charged ion. Cations measured by CASTNet include particulate ammonium ( $\text{NH}_4^+$ ), particulate calcium ( $\text{Ca}^{2+}$ ), particulate magnesium ( $\text{Mg}^{2+}$ ), particulate potassium ( $\text{K}^+$ ), and particulate sodium ( $\text{Na}^+$ ). Cations can neutralize acid deposition if sufficient cation concentrations are available.

**Clean Air Act:** A federal law that protects the quality of air in the United States. Current law is based on legislation passed in 1970. The Clean Air Act Amendments of 1990 (CAAA) mandated, among other things, establishment of a national air monitoring network (e.g., CASTNet) to track air quality as mandated emission reductions were

implemented. The main objective of the law is to protect public health. The law also works to protect the environment from damage and degradation by air pollution.

**Clean Air Status and Trends Network (CASTNet):** Established in 1991, CASTNet is a national air monitoring network created by EPA, in cooperation with NOAA, from the National Dry Deposition Network in response to the mandate of the 1990 Clean Air Act Amendments that required formation of a long-term monitoring program to track real-world environmental results as promulgated emission reductions were implemented. The network measures changes in air quality and atmospheric deposition over broad geographic regions of the United States. CASTNet's objectives are to define the geographic distribution of pollutants and atmospheric deposition fluxes, detect and quantify long-term trends in pollutants and deposition, and provide data on the dry deposition component of acid deposition and ground-level ozone. CASTNet is the nation's primary source of information on the dry deposition component of total acid deposition and on rural, ground-level ozone. EPA operates CASTNet in partnership with NPS. As of December 2002, EPA sponsored 54 CASTNet sites and NPS sponsored 30.

**collocated sampling:** Two samples taken at the same time in the same location by separate, yet identical instruments. The instruments are placed just far enough apart so as not to interfere with each other (i.e., wind turbulence). The samples are then analyzed in the laboratory using the same protocol. Producing precise weekly pollutant measurements challenges every element of the measurement and analytical systems. The collocated systems provide a means to gauge instrument precision, which is one of CASTNet's data quality indicators.

**complex terrain:** Forested, mountainous terrain.

**concentration:** The amount of a chemical contained in a unit of air. Concentration is expressed as micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), parts per billion (ppb), or parts per million (ppm).

**continuing verification sample (CVS):** Continuing verification samples are samples with known values that approximate the midpoint of the analytical range of the analyte being analyzed. CVS are independently prepared by an outside laboratory that is different from the laboratory that prepares the reference samples. CVS for CASTNet are obtained from the National Institute of Standards and Technology (NIST) or from a source that is traceable to NIST. Consistency of instrument response throughout the entirety of the analytical run is determined by analyzing an independently prepared CVS after every 10 environmental samples in each batch of samples and then calculating the percent recovery relative to the target (theoretical) value. The percent recovery must be within DQI limits.

**continuous measurements:** As part of the long-term air monitoring mandated by the CAAA, CASTNet instruments sample ambient air flow and measure ozone and meteorological parameters continuously (i.e., 24 hours a day, seven days a week).

**criteria air pollutants:** Six widespread and common air pollutants that have been determined to be hazardous to human health and/or the environment. These pollutants include ozone, carbon monoxide, particulates, sulfur dioxide, lead, and nitrogen oxide. As mandated by the Clean Air Act, EPA regulates concentrations of these pollutants through National Ambient Air Quality Standards.

**data quality indicator (DQI):** A statistically and scientifically evaluated standard of achievement used to gauge the level of acceptance and usability of data obtained both in the field where the samples are collected at the monitoring sites and in the laboratory where the collected samples are analyzed. Continual verification that data obtained from both field and laboratory measurements meet specific criteria ensure that the data reliably present a true picture of the quantity of those pollutants in the air sampled and of the meteorological conditions used by the Multi-Layer Model. CASTNet DQI are precision, accuracy, completeness, bias, representativeness, and comparability.

**data validation:** Processes to verify that the data are of a known quality. Data undergo several stages of data verification to ensure that they are as precise, accurate, complete, and usable as possible to meet end-user needs. All steps taken during the data validation process are documented. In general, Level 0 involves the transfer of data from the site to the database; Level I completes the data set in the database through recovery of missing data from backup sources; Level 1x is a pre-validation check to verify inaccuracies and status flags for flow and ozone data and to review the field data validation recommendations in the Field Problem Report module of the CASTNet Data Management System Application; Level II is the final, investigatory procedure that reviews all documentation and data. Data are considered to be completely validated and finalized after completion of Level II validation.

**delta temperature:** The difference between the temperatures measured at heights of 2 meters and 9 meters.

**deposition velocities ( $V_d$ ):** The rate at which particles are deposited to the environment. Calculation of deposition velocities simulates the influences of meteorological conditions, vegetation, and atmospheric chemistry on the deposition of particles. The Multi-Layer Model is used to calculate  $V_d$ .

**deposition week:** See sampling week.

**diurnal:** A 24-hour cycle. Occurs or is completed every 24 hours.

**dry deposition:** A form of acid deposition in which acidic compounds formed from emissions of sulfur, nitrogen, and other substances are deposited to the environment in the absence of precipitation as gases and dry particles. Wind often transports the dry compounds of sulfur and nitrogen oxides to areas far from the original source. See “The Perfect Dust Storm” in Chapter 2 of the CASTNet 2001 Annual Report (Harding ESE, 2002) for an example of distance dust travels. Concentrations of dry particles and gases not only upset ecosystems and cause damage to the environment, but also can irritate the lungs and cause respiratory diseases when inhaled.

**eastern sites:** Those sites east of 100 degrees west longitude.

**emission:** A release or discharge of pollutants into the atmosphere from a specific source or point of origin.

**Environmental Protection Agency (EPA):** See United States Environmental Protection Agency.

**field blanks:** See trip blanks.

**filter pack:** an open-face, three-stage filter pack used to collect air samples for analysis. Particles and selected gases are collected by passing air at a controlled flow rate through a sequence of Teflon<sup>®</sup>, nylon, and dual potassium carbonate impregnated Whatman filters mounted in a Teflon<sup>®</sup> assembly. See Figure 1-2 for a diagram of the filter pack.

**flux:** Rate of dry deposition of pollutants to the environment. Flux is calculated as the product of the hourly deposition velocity obtained from the Multi-Layer Model and the corresponding hourly concentration.

**Government Performance and Results Act:** Legislation passed in 1993 to direct government agencies to adjust their focus away from only their activities and to concentrate on the results of their activities. As a result of this legislation, agencies such as EPA seek to develop multiyear plans with long-term goals (i.e., “to see the forest instead of the trees”). CASTNet provides the means to track the long-term results of air pollution controls.

**Interagency Monitoring of Protected Visual Environments (IMPROVE):** Established in 1985, IMPROVE is a long-term monitoring program to track visual air quality in sensitive areas of national parks and other designated wilderness areas.

**in-run replicate:** Five percent of the samples in each laboratory batch that is analyzed are randomly selected for re-analysis. The result of the re-analysis is then compared to the original result. The difference between the two is calculated as the relative percent difference (RPD). The RPD from in-run replicates is used to determine the precision of the analytical run (i.e., if the RPD of the analyses fall within limits specified by the associated DQI).

**inversion layer:** Atmospheric condition that occurs when a layer of cool air is trapped at or near ground level by a layer of warm air. Since the colder, heavier air is trapped below the warmer air, upward currents are unlikely to form and pollutants cannot dissipate. Pollutant levels in the horizontal air layer will continue to increase until the air mass layers disperse.

**laboratory blank:** Laboratory blanks are prepared at the same time as the filters are prepared for the filter packs. The filters selected for laboratory blanks are placed directly into the extraction bottles. Two separate laboratory blank samples are prepared each week with the filter packs. The laboratory blanks are prepared and analyzed in the same manner as the field samples. The laboratory blanks and field samples for a given week are extracted and analyzed together. Laboratory blanks are used as a quality control method to detect contamination or bias introduced during filter pack preparation, transport, storage, and analysis.

**leaf area index (LAI):** The one-sided, green leaf area of the plant canopy per unit area of ground at full leaf emergence. LAI provides information on the plant canopy, showing how much of the surface is covered by vegetation relative to total ground surface. LAI and information on vegetation play an important role in Multi-Layer Model calculations to model dry deposition flux.

**Level 1x:** See data validation.

**Level I:** See data validation.

**Level II:** See data validation.

**level of quantitation:** The minimum detectable concentration of a substance that can be determined within specified limits of precision during routine analysis.

**local temperature and pressure:** Local temperature is the actual temperature at the site. The temperature is converted from Celsius to Kelvin for determination of “local” atmospheric concentrations. Pressure is not currently measured at CASTNet sites, so elevation is used to estimate the pressure for each site.

**long-range transport:** Once pollutants are airborne they can be carried long distances before settling out of the atmosphere onto the environment. While pollutants are airborne, they react with temperature, particles, water droplets, oxygen, and oxidants to undergo complex chemical changes. For example, sulfur dioxide ( $\text{SO}_2$ ), a primary pollutant, is generally found within a source region (i.e., near the emission point). As sulfur dioxide travels in the atmosphere it changes through photochemical reactions into sulfate ( $\text{SO}_4^{2-}$ ). Sulfate is a secondary pollutant and is more uniformly distributed inside and outside of the source region. A high level of sulfate without the corresponding level of sulfur dioxide suggests emissions from distant sources.

**meteorological parameters:** Weather-related measurements. CASTNet measures wind speed, wind direction, sigma theta, relative humidity, solar radiation, precipitation, ambient temperature, delta temperature, and surface wetness.

**method blanks:** Contain each reagent used in the laboratory analysis being performed and are run with each analytical batch to assess reagent integrity. Method blanks do not contain filter media.

**monitoring:** Measuring air pollution.

**Multi-Layer Model (MLM):** A mathematical computer model used to estimate dry deposition. The MLM was developed by the NOAA Atmospheric Transport and Diffusion Division, Oak Ridge, TN and the Atmospheric Science Modeling Division, Research Triangle Park, NC. It is applied through a 20-layer canopy in which model parameters are modified by the redistribution of heat, momentum, and pollutants. The MLM requires input of data for wind speed, wind direction, sigma theta, temperature, relative humidity, solar radiation, surface wetness, leaf area index, vegetative species, and percent green leaf-out. The model accounts for water and temperature stress, stomatal resistances of vegetation, and deposition to snow surfaces. Current dry deposition calculations for CASTNet sites are made using a version of the MLM that was updated in 2002.

**National Acid Precipitation Assessment Program (NAPAP):** Established in 1980, NAPAP is an interagency monitoring and assessment program that conducts research on the effects of sulfur and nitrogen oxides, particularly as acid rain, on the environment and human health. NAPAP is a cooperative program of federal and state agencies working with universities, the private sector, and others. The six government agencies that comprise NAPAP are the National Oceanic and Atmospheric Administration (NOAA), EPA, Department of Energy (DOE); Department of the Interior (DOI), and the Department of Agriculture (USDA).

**National Ambient Air Quality Standards (NAAQS):** Regulations established by EPA as mandated by the Clean Air Act to control criteria air pollutants, such as ozone. Areas with levels of criteria air pollutants that exceed NAAQS are considered to be nonattainment areas.

**National Atmospheric Deposition Program (NADP)/National Trends Network (NTN):** NADP, a national monitoring program, began in 1978 as a cooperative program between federal and state agencies, universities, electric utilities, and others to determine precipitation and wet deposition across the United States. NADP merged with NTN in the 1980s. NADP/NTN, with more than 200 sites, is the nation's primary source of information on the wet deposition component of total acid deposition.

**National Dry Deposition Network (NDDN):** An air monitoring network established by EPA that began operation in 1986 to obtain field data on dry acid deposition in rural areas. NDDN was merged into CASTNet in 1991. The approximately 50 NDDN sites became the core CASTNet sites. Like CASTNet, NDDN measured changes in air quality and atmospheric deposition over broad geographic regions of the United States.

**National Park Service (NPS):** Established in 1916 under the Department of the Interior, NPS is responsible for protecting our national parks and preserving them “unimpaired” for the enjoyment of all who use them now and for future generations to come. This responsibility includes the protection and enhancement of air quality related resources in national parks and wilderness areas. In 1994 NPS entered into a partnership with EPA to operate air monitoring sites under a common set of CASTNet protocols.

**nitrogen oxides (NO<sub>x</sub>):** Nitrogen oxides are formed during the burning of fossil fuels such as gasoline and coal and are a contributor to the formation of ground-level ozone (smog). Nitrogen oxides play an major role in the production of acid deposition.

**nonattainment area:** A geographic area in which the level of a criteria air pollutant (such as ozone) is higher than the level allowed by federal law. National Ambient Air Quality Standards are used to regulate allowed levels of criteria air pollutants.

**oxidation:** A chemical reaction in which oxygen combines with other elements converting them to other compounds.

**ozone (O<sub>3</sub>):** A gas that is a reactive form of oxygen. Ozone is a compound of three atoms of oxygen and naturally occurs in high concentrations in the stratosphere where it shields the Earth from harmful rays from the sun. At ground-level (troposphere), ozone is the main component of smog and can seriously affect the human respiratory system. Ozone is one of the six criteria air pollutants regulated by National Ambient Air Quality Standards.

**particles/particulate:** A criteria air pollutant. Very small pieces of solid or liquid matter suspended in the atmosphere and transported through the air. These particles are emitted into the atmosphere in various forms such as smoke, dust, fumes, mist, or aerosol. CASTNet measures concentrations of particulate sulfate (SO<sub>4</sub><sup>2-</sup>), nitrate (NO<sub>3</sub><sup>-</sup>), ammonium (NH<sub>4</sub><sup>+</sup>), calcium (Ca<sup>2+</sup>), magnesium (Mg<sup>2+</sup>), sodium (Na<sup>+</sup>), and potassium (K<sup>+</sup>).

**Phase I and Phase II emission reductions:** Phase I began in 1995 and required emissions reductions at 435 large electric generating plants burning mostly coal in eastern and mid-western states. Phase II, which began in 2000, increased the restrictions on the Phase I plants and set restrictions on smaller electric generating plants. More than 2,000 plants are affected by Phase II.

**photochemistry:** An atmospheric process relating to the reaction between chemicals and sunlight. For example, volatile organic carbons and nitrogen oxides react in sunlight to form ozone or other photochemical oxidants. Sunlight is a major factor in the production of smog.

**photolysis:** Caused by solar radiation, a type of chemical decomposition.

**primary pollutants:** Types of pollutants emitted directly from a source. CASTNet tracks the status and trends of SO<sub>2</sub>.

**quality assurance (QA):** A system for ensuring that the data obtained are accurate, meet defined standards of quality, and can be used confidently for the required purpose. QA systems utilize specific procedures, checks, audits, and corrective actions to ensure all facets of operation and reporting from the planning stage to the archiving of data meet or exceed set standards.

**quality control (QC):** Routine application of tests, checks, inspections, and other activities to ensure that sample collection and analysis proceed as expected. Quality controls are designed to catch errors or instrument failures in the early stages before significant damage can be done.

**reference sample:** Reference samples are samples with known values that are independently prepared by an outside laboratory that is different from the laboratory that prepares the continuing verification samples. Reference samples used for CASTNet are obtained from the National Institute of Standards and Technology (NIST) or are from a source that is traceable to NIST. Accuracy of laboratory measurements is determined by analyzing an independently prepared reference sample in each batch of samples and calculating the percent recovery relative to the target (theoretical) value. The percent recovery must be within DQI limits.

**reference sites:** Thirty-four eastern CASTNet sites used for calculating long-term trends. These sites were selected using criteria similar to those used by EPA in its National Air Pollutant and Emissions Trends Report (2000). Sites with complete data for at least 11 of 13 years were selected. See Figure 1-1 (Chapter 1) for the location of the reference sites.

**sampling week:** 168 hour period from 0900 Tuesday to 0900 the following Tuesday.

**scalar wind speed:** The arithmetic average of wind speed without consideration to changes in wind direction.

**scavenging:** Removing air pollution from the atmosphere by uptake in precipitation.

**secondary pollutant:** Pollutants that are not directly emitted from a source, but are the result of atmospheric processes reacting with the primary pollutants. Sulfate is an example of a secondary pollutant formed from the primary pollutant, sulfur dioxide.

**short ton:** Equal to 2,000 pounds or 0.97 metric tons.

**sigma theta:** The standard deviation of horizontal wind direction within one hour.

**source regions:** Regions of the United States that emit large amounts of air pollutants such as SO<sub>2</sub>.

**standard temperature and pressure:** CASTNet sites are operated and calibrated to measure flow rates through the three-stage filter pack at standard temperature and pressure conditions. Standard temperature is equal to 25 degrees Celsius and standard pressure is equal to the pressure at sea level elevation.

**stratosphere:** Upper atmosphere approximately 9 to 31 miles above the Earth's surface (depending on location).

**sulfur dioxide (SO<sub>2</sub>):** A criteria air pollutant. Sulfur dioxide is a gas produced during the burning of fossil fuels, which contain sulfur, such as coal and oil. Sulfur dioxide plays an important role in the production of acid deposition.

**SUM06:** The measure of vegetation and crop exposure to ozone during the growing season. SUM06 is calculated as the sum of hourly daytime ozone concentrations above 0.06 ppm summed over 12 hours (i.e., 0800 to 2000) during a 3-month period. SUM06 had been proposed by EPA as a secondary standard with a numerical limit of 25 ppm-hours.

**trip blanks:** Trip blanks are a quality control tool. A trip blank, also known as a field blank, is a filter pack that has been assembled at the same time using the same protocols as the standard filter packs used for field sampling. It is then sealed in an air-tight plastic bag, labeled as a trip (field) blank and sent to the site with a regular filter pack. The trip blank remains sealed in the plastic bag while at the sampling site and is returned with the regular filter. The filters in the trip blank are then analyzed and processed exactly as the exposed filters. Analysis of trip blanks provides a means of measuring background contamination introduced during filter pack preparation, transport, and storage.

**troposphere:** The lowest region of the atmosphere. The troposphere extends to a height of 8 to 15 kilometers above Earth and is the atmospheric layer in which weather occurs. It is also characterized by decreasing temperature with increasing altitude.

**tropospheric ozone:** Ozone in the troposphere.

**United States – Canada Air Quality Agreement:** An agreement signed in 1991 between the United States and Canadian governments concerning transboundary air pollution and efforts to control and reduce it through cooperative and coordinated efforts between both countries.

**United States Environmental Protection Agency:** A federal agency established in 1970 to protect human health and to safeguard the environment. EPA develops and enforces environmental regulations, performs environmental research, and promotes environmental education and awareness.

**vector wind speed:** The vector average of wind speed and wind direction.

**volatile organic carbons (VOC):** Chemicals containing carbon that vaporize easily. VOC will readily evaporate at room temperature. Some VOC are also hazardous air pollutants.

**western sites:** Those sites west of 100 degrees west longitude.

**wet deposition:** A form of acid deposition in which acidic compounds formed from emissions of sulfur, nitrogen, and other substances are washed out of the atmosphere as dilute sulfuric and nitric acids and deposited to the environment. Wet deposition can occur by way of rain, fog, snow, sleet, and other forms of precipitation. Forms of wet deposition such as acid rain, fog, and snow upset the balance of ecosystems and cause damage to forests, lakes, and rivers and agricultural lands and crops. Wet deposition also causes corrosion to buildings, vehicles, and other man-made products.